A new species, a new combination and a new subsection of *Cycas* from Odisha, northern Eastern Ghats of India

Rita Singh1, P. Radha2 and J.S. Khuraijam3

1University School of Environment Management, GGS Indraprastha University, Dwarka 16C, New Delhi – 110 078, India
2Centre for Plant Molecular Biology, Osmania University, Hyderabad – 500 007, India
3Botanic Garden, CSIR-National Botanical Research Institute, Rana Pratap Marg, Lucknow – 226 001, India

(Accepted June 15, 2015)

**ABSTRACT**

*Cycas circinalis* var. *orixensis* Haines (Cycadaceae) is raised to species rank and a new species, *Cycas nayagarhensis* is described and illustrated from the state of Odisha in the northern Eastern Ghats of India. Both of these Odisha *Cycas* species described here, have characteristic megasporophylls having spinescent lateral teeth and a spear-like long apical spine. Male cones are the most peculiar in having microsporophylls with upturned, one to variously forked apical spines. *Cycas nayagarhensis* is distinguished from *C. orixensis* by its massive arborescent stem, large male cones, with microsporophylls having entire or variously forked apical spine and radially compressed ovules. A comparative table of the northern Eastern Ghats *Cycas* and a key to all the Indian species are provided. The infrageneric classification of the genus *Cycas* is modified and a new Subsection Orixenses under Section *Cycas* is created here to accommodate these two morphologically distinct endemic taxa from Odisha.

**Key words**: *Cycas orixensis*, *Cycas nayagarhensis*, Eastern Ghats, Odisha, India

**INTRODUCTION**

In 1924, Haines described *Cycas circinalis* var. *orixensis* from Orissa (now Odisha). He described the taxa on the basis of forked tips of the microsporophylls in male cones and comparatively longer spinescent apical spine and lateral spines in megasporophylls. Though he did not cite any type, he mentioned about its occurrence in wild in the hill forests of the Mals of Puri which extends northward up to Angul. In “Flora of Madras Presidency”, Gamble (1928) reported only two species of *Cycas* namely *C. circinalis* and *C. beddomei*. In cayc taxonomy, male cone characters are usually not used for differentiating taxa (Walters et al., 2004) and as a rule, the basic morphology of the mature microsporophyll is found to be fairly uniform in having a wedge shaped fertile part which expands distally from a narrow point of attachment and bears a large number of microsporangia on its abaxial surface followed by a sterile end part which usually tapers into a pointed or truncated, upcurved, unbranched apex (Whitelock, 2002; Jones, 2002). Forked apical spine of the microsporophyll in the generally known morphological nature of microsporophyll is considered to be as an “abnormality” (De Laubenfels, 1999; Jones, 2002; Whitelock, 2002). Characteristic forkings in the microsporophylls as mentioned by Haines could not be examined by later authors as all the herbarium collections housed at Kolkata, Dehradun and Kew have specimens of either leaves or sterile megasporophylls.

Hill and Lindstrom (2007) synonymised *C. circinalis* var. *orixensis* under *Cycas sphaerica* Roxb., from the plants under cultivation in the Royal Botanic Gardens, Sibpur, Howrah (now known as Acharya Jagdish Chandra Bose Indian Botanic Garden). The plants were said to have been introduced from the Moluccas in 1798-9, Roxburgh’s herbarium collection at CAL. Howrah have only the parts of megasporophyll and vegetative leaves (CAL: Roxburgh 448261-73), microsporophylls are not preserved as was the case with *Cycas circinalis* var. *orixensis*. Hill and Lindstrom believed *Cycas sphaerica* Roxb. originated from Odisha and according to them “this species is similar to *Cycas circinalis* in most respects, differing in the broader megasporophyll apex with longer teeth” and is distributed in Odisha, Tamil Nadu, Karnataka and Andhra Pradesh (Lindstrom & Hill 2007). During our field survey and taxonomic study of *Cycas* over several years in Odisha and adjoining areas, we have concluded that Odisha *Cycas* populations have distinctive male and female cone characters.

On the basis of variously forked apices in the microsporophylls and characteristic spinescent lateral teeth and a spear-like long apical spine of megasporophylls, *Cycas circinalis* var. *orixensis* is raised to the rank of species, *Cycas orixensis* (Haines) R. Singh and J.S. Khuraijam comb. et stat. nov. This species is distributed in six districts of Odisha state namely Angul, Boudh, Dengkanal, Ganjam, Kendujhar and Mayurbhanj. During field surveys in Central Odisha in the district of Nayagarh, few populations having more robust habit and different and distinct morphological features from *Cycas*...
orixensis were discovered. These populations are described and illustrated here as a new species, *Cycas nayagarhensis* R. Singh, P. Radha & J.S. Khuraijam sp. nov.

A new subsection is added in the infrageneric classification of the genus *Cycas* (sensu Hill, 1995) to accommodate these two distinct species, *C. orixensis* (Haines) R. Singh and J.S. Khuraijam comb. et stat. nov. and *C. nayagarhensis* R. Singh, P. Radha & J.S. Khuraijam sp. nov. which are endemic to the northern Eastern Ghats of India.

Section *Cycas*

A Subsection *Cycas*

B Subsection *Orixenses* R. Singh and J.S. Khuraijam, subsect. nov.

Masculum coni unus-multis-furcatis, spinsecent apicalibus de microsporophyll, feminam sporophyll longiori spinsecent lateralibus et dentes et diu prominent apicalibus spine.


This new subsection is characterised by the one- to many- forked, spinsecent apical spine of the microsporophyll, female sporophyll with longer spinsecent lateral teeth and a long prominent spear-like apical spine. The subsection contains *C. orixensis* (Haines) R. Singh & J.S. Khuraijam comb. et stat. nov. and *C. nayagarhensis* R. Singh, P. Radha & J.S. Khuraijam sp.nov.

C Subsection *Endemicae*

D Subsection *Rumphiæ*

*Cycas orixensis* (Haines) R. Singh & J.S. Khuraijam comb. et stat. nov.

**Basionym:** *Cycas circinalis* var. *orixensis* Haines, Bot. Bihar Orissa 6: 1228 (1924).

**TYPE:** India, Odisha, Mals of Puri, Haines 5876, June 1917 (syn. K); Angul, Haines 5877, July 1917 (syn. K).

**EPITYPE:** India. Odisha: Angul District, Mar. 2010. R. Singh and J.S. Khuraijam, designated here – 67636 (†) (currently housed at Herbarium, USEM, GGS Indraprastha University, New Delhi shall be deposited in CAL, Howrah). (Figs. 1-3)

Planta arborescens; microsporophyllis obturrillatis, perpendicularibus, spina apicalis inflexa, integra vel 1-multipulcata, fucris inaequalibus.

Trunk tall slender, upto 6 m in height, 12.5-32 cm in diam., generally unbranched older plants usually without persistent armour of leaf bases. Photosynthetic leaves pinnately compound with 40-96 pairs of pinnae, 70-190 cm long, dark green, discolorous, glabrous, petiole 20-30 cm long with 14-26 pairs of spines. Median pinnae 18-25 cm long, 7-15 mm wide, 7-10 mm apart, decurvately attached to the adaxial surface of the rachis at an angle of 40º-50º. In cross-section, pinnae show 2 to 3 mucilage canals towards the abaxial (phloem side) of the vascular bundle. Male cones ovoid, yellowish-orange turns orangish red during peak of the day at the time of anthesis or pollen dispersal, 11-21 cm long, 10-12 cm in diameter. Spirally arranged microsporophylls have obtrullloid lamina, 40-45 mm long, 12-20 mm wide; fertile zone 23-29 mm long, sterile apex sharply upturned or inflexed (towards ventral side) into apical spine; apical spine 22-38 mm long; entire or forked, forking usually unequal, generally 1-3 however, a number of irregularly arranged protuberances and blunt spines were also observed below the apical spines along the margins of the apophysis. Female cones compact spirally arranged when young and laxes at maturity. Megasporephylls tomentose, amber coloured, 12-23 cm long, lamina dorsiventral, lanceolate, 45-75 mm long, 20-38 mm wide having 12-20 lateral spines on either side; lateral spines entire or occasionally forked, 6-17 mm long, 1-3 mm wide at the base, apical spine spear-like, 20-40 mm long, 4-8 mm wide. Ovuliferous region 5-9 cm long, ovules 2-6, glabrous, sessile, orthotropus, attached laterally, spheroidal to broadly ellipsoidal in shape, 30-34 mm long, 28-32 mm in diameter, sarcotesta after fertilisation turns yellow to mango-yellow at the time of shedding, 2-4 mm thick, fibrous layer present, sclerotesta stony, endotesta membranous, spongy tissue absent. Seeds platyspermic. Germination cryptocotylor.

**Distinguishing characters.** — *Cycas orixensis* is distinguished from *C. circinalis* by its slender trunk (12.5-32 cm diam.); entire or differently forked nature of the apical spine of the microsporophyll; character of sterile apex of the megasporophylls; size, shape, color, and number of the ovules. It is also distinct from *C. sphaerica* Roxb. in having microsporophyll with one – to many-forked apical spines and the lanceolate lamina of megasporophylls with a long, prominent spinsecent apex. Although Lindstrom and Hill (2007) synonymised *Cycas circinalis* var. *orixensis* under *C. sphaerica*, our observation over a period of 2007-2012 shows forked character of microsporophylls of *C. orixensis* is entirely restricted to Odisha populations. However, female and male cones of *Cycas* populations in Srikakulam, Andhra Pradesh resemble morphologically to *Cycas sphaerica* (Lindstrom and Hill, 2007). None of the vouchers deposited at CAL have preserved microsporophylls. In that case, we assign *Cycas* populations of Srikakulam described by earlier authors to *C. sphaerica*.

**Distribution and Ecology.** — *Cycas orixensis* is distributed from Mayurbhanj, Kendujhar, Dengkanal, Angul in north and crossing Mahanadi River up to Boudh in Central Odisha. The distribution of the species further extends upto Ganjam district in southern Odisha (Fig. 7). They are generally understory constituents of the tropical moist deciduous forest having *Shorea robusta* Gaertner, *Dendrocalamus strictus* Nees and *Bambusa arundinacea* Willd. as dominant species. In Satkosia Tiger Reserve which embraces part of Boudh and Angul, the habitats are swampy and remain inundated during monsoon months of
Figure 1. Cycas orixensis (Haines) R. Singh and J.S. Khuraijam comb. et. stat. nov. A. Male cone with differently forked apical spines. B-D. Microsporophylls; lateral view showing inflexed apical spine, lower surface (dorsal) with microsporangia; upper surface (ventral). E. Magnified sterile tip of the microsporophyll. F. A megasporophyll. G. Median part of the leaf. H. Cross section of a pinna showing one side of the lamina. I. Longitudinal section of an ovule showing sarcotesta (sar), fibrous layer (Fib. layer), Sclerotesta (Scl), Endotesta (End). J. Ovule, top view. K. Mature seed with intact sarcotesta. Scale bar: 1 cm.
Figure 2. *Cycas orixensis* (Haines) R. Singh and J.S. Khuraijam comb. et. stat. nov. **A.** female plant bearing megasporophylls. **B.** A crown of loosely arranged megasporophylls with intact mature seeds. **C.** Male cone. **D.** Magnified male cone showing forked microsporophylls. **E.** A megasporophyll. **F.** Magnified view of the sterile lamina showing apical and lateral spines. **G.** Entire ovule. **H.** Magnified view of the sterile lamina showing forked lateral spines. **I.** Section of ovule. **J–L.** Microsporophylls with differently forked tips and dentate margin of the apophyses (J – Lower surface, K – Upper surface, L – Lateral surface). **M, N.** Forked sterile tip of the microsporophyll (Top view). Scale bar: 1 cm.
June to August, they are mostly associated with members of Zingiberaeae and Dipterocarps. The male plants of the southern populations of Ganjam start coning much ahead of the northern populations of Angul and Boudh. Northernmost distribution of Cycas orixensis occur in Mayurbanj district where it grows in Simlipal Tiger Reserve. The species also grow in Kendujhar district which lie on the south of Mayurbanj district.

*Phenology.* — Male plant start coning in mid or late March and female plant start producing megasporophylls in May-June.

*Vernacular names.* — Cycas orixensis is known by several names in Odisha: Aruguna, Oruguna, Orguna, Oranga and Odissimari. These names changes along with their ethnic uses.

*Conservation status.* — Cycad populations in the region are under anthropogenic threat primarily due to decimation, clearing and transformation of the uphill forests into cultivable land and secondly due to prevalent practice of harvesting leaves and shoot apex for religious and cultural activities and fertilized ovules or seeds prior to their shedding by the local people and tribals residing in the vicinity of the natural populations. Male cones are also harvested and used as pesticides. The species may be currently regarded as Endangered C2(ai) [IUCN Redlist Categories and Criteria (Ver. 9, 2011)].

*Selected specimens examined.*

**INDIA. Odisha:** Mals of Puri, *Haines 5876, 5877 (♀), June 1917* (K – images K000077087, K000077088); Angul, *Haines 18520 (♀), August 1917* (DD); Athamallik, Hathidhara Block, *H. F Mooney 2867 (♀), May 1947* (DD).

**Topotypes:**


**Additional specimens examined:**

*West Bengal:* CAL (currently known as Central National Herbarium), Howrah, *Roxburgh 448261, 448262, 448263, 448264, 448265, 448266, 448267, 448268, 448269, 448270 (♀), Jan. 1883; 448271, 448272, 448273 (♀), Aug. 1882.

**Cycas nayagarhensis** R. Singh, P. Radha & J.S. Khuraijam *sp. nov.*

**TYPE:** INDIA. Odisha: Nayagarh, May 2009, *R. Singh & J.S. Khuraijam* (Holotype: 67409, currently housed at Herbarium, USEM, GGS Indraprastha University, New Delhi shall be deposited at CAL, Howrah).

(Figs.4-6)

Planta arborescens; robustum trunco latior basi fastigatis apice, amplus ovoideae masculum conos, interdum furcatae, sterile apicem microsporophylls.

Stem arborescent, branched or unbranched, up to 5 m tall, 50-92 cm diameter. Bark thick with alternate bands of persistent leaf bases and cataphylls in young plants and smooth in mature trees. Photosynthetic leaves pinnately compound with 80-176 pairs of pinnae, 104-210 cm long.
Figure 4. Cycas nayagarhensis R. Singh, P. Radha and J.S. Khuraijam sp. nov. A. A male cone. B. Median part of the leaf. C-E. Microsporophylls; lower surface (dorsal) with microsporangia; upper surface with forked sterile apex and lateral view. F. Magnified sterile tip of the microsporophyll. G. Cross section of a pinna showing one side of the lamina. H. Longitudinal section of an ovule showing sarcotesta (sar), fibrous layer (Fib. layer), Sclerotesta (Scl), Endotesta (End). I. Mature seed with intact sarcotesta. J. A megasporophyll. Scale bar: 1 cm
Figure 5. *Cycas nayagarhensis* R. Singh, P. Radha and J.S. Khuraijam sp.nov. A. Robust habit. B-C. Male cone. D. Magnified portion of male showing sterile apex. E. Microsporophyll with forked sterile apex. F-I. Microsporophylls (F. upper surface. G. lower surface. H. lateral view, and I. lower view showing lateral spines). Scale bar: 1 cm

Scale bar: 1 cm
Cycas of northern Eastern Ghats, India

glossy (glaucous), bluish green in colour. Petiole 28-47 cm long, spinescent, spines 18-29 pairs. Pinnae lanceolate, glabrous, discoulourous, margin entire beak shaped in cross section with ventrally prominent midrib. Median pinnae 19-28 cm long, 6-10 mm wide and attached to the rachis at 50-55°. Male cone ovoid, sub-conical, 18-43 cm long, 10-20 cm in diameter, yellow orange in colour. Microsporophylls 40-50 mm long, 20-25 mm wide, fertile zone 30-34 mm long, apical spine stout, upturned, 22-30 mm long, entire, occasionally forked. Female cones compact when young and mega-sporophylls loosely arranged on maturity. Megasporophylls tomentose, 12-19 cm long, lamina dorsiventral, lanceolate, 70-85 mm long, 28-37 mm wide, 13-25 lateral spines on either side, lateral spines entire, 4-9 mm wide at the base, apical spine 30-46 mm long. Ovuliferous region 6-12 cm long, ovules 1-6, glabrous, sessile, laterally compressed, spheroidal to broadly ellipsoidal, 33-38 mm long, 35-39 mm in diameter, green when young turn mango yellow at maturity, sarcotesta 40-50 mm thick, fibrous layer present, sclerotesta stony. Seeds platyspermic.

Etymology. — The specific epithet is named after the district Nayagarh in Odisha where this species is naturally found in three populations.

Distribution and Ecology. — Cycas nayagarhensis is reported from three populations in Nayagarh district of Odisha: Gamein Hills, Rukhi Hills and Balram Hills. This species grow on the open sandstone rocky hills at an elevation of 135-180 m.

Phenology. — Female cones start emerging in June-July and male cones in March-May.

Vernacular names. — Aruguna, Oruguna, Orguna, Oranga and Odissimari.

Conservation status. — Populations of Cycas nayagarhensis are severely affected by hacking of stems for religious and cultural rituals. Land transformation due to expansion of Nayagarh city has resulted in steep decline in the cycad population. The species grow only in three elevated localities Rukhi, Balram and Gamein with only few plants. Considering its small population size with very few mature trees, the species can be enlisted as Critically Endangered, B2ab(iii,v) [IUCN Redlist Categories and Criteria (Ver. 9, 2011)].

Notes: The stem of Cycas nayagarhensis resemble C. swamyi (Singh & Radha, 2008) in having columnar stem of equal diameter except for the broader base. The megasporophylls of C. nayagarhensis are covered with yellow-orangish hair and have pointed spear-like long apical spine ca 30-40 mm. Cycas nayagarhensis differ from C. circinalis in having forked tip of microsporophyll, and occasionally forked lateral spines and prominent spear-like apical spines of megasporophylls.

Selected specimens examined.  

Distinguishing characters. — Large trunk (50-92 cm in diam.), wider at base tapering apically, large ovoid male cones, occasionally forked sterile apex of the microsporophylls.

Figure 7. Map of Odisha showing distribution of Cycas orixensis (Haines) R. Singh and J.S. Khuraijam comb. et. stat. nov. and Cycas nayagarhensis R. Singh, P. Radha and J.S. Khuraijam sp.nov.
Table 1. Comparative morphological characters of northern Eastern Ghats *Cycas* and *Cycas circinalis* L.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Habit and Stem</td>
<td>Stem arborescent, 5 m tall, columnar, sometime branched, 18-83 cm in diam.</td>
<td>Stem arborescent, 5m tall, 9-27 cm diameter, base not strongly swollen, dark thick with persistent leaf bases and cataphylls.</td>
<td>Stem arborescent, branched or unbranched, up to 5 m tall, 50-92 cm diameter. Bark thick with alternate bands of persistent leaf bases and cataphylls when young and smooth in mature plants.</td>
</tr>
<tr>
<td>Leaves</td>
<td>Leaves 1-2.5 m long with 100-120 pairs of pinnae. Petiole 50-70 cm long, spinescent, spines ca. 2.5 mm long. Medium pinnae 30-35 x 0.9-1.4 cm.</td>
<td>Dark green, semiglossy, 95-185 cm long, flat (not keeled) in section, (opposing leaflets inserted at 180° on rachis), with 55-130 leaflets, with newly emerging leaves light green and lacking tomentum because tomentum sheds very early as leaf expands. Petiole 27-50 cm long, glabrous, spinescent for 20-100% of length. Leaflet 18-27 cm long, 0.7-1.2 cm wide</td>
<td>Leaves 1.04-2.10 m long with 80-176 pairs. Petiole spinescent, 28-47 cm long, spines 18-29 pairs. Pinnae lanceolate, margin entire and glabrous with prominent midrib. Median pinnae 19-28 cm long × 0.6-1 cm wide and attached to the rachis at 50-55°.</td>
</tr>
<tr>
<td>Male cone</td>
<td>Male cone oblong to oval, deep yellow to orange in colour, 30-50 cm long. Microsporophylls 3.1-8.1x1.4-2.5 cm. Fertile zone 1.9-4.0 cm long, sterile zone length 1.5-4.2 cm.</td>
<td>Narrowly ovoid, orange, c.45 cm long, c. 10 cm diameter, microsporophyll lamina firm, not dorsiventrally thickened, 32-38 mm long, fertile zone 28-34 mm long, sterile apex c. 4 mm long, merging with apical spine; apical spine prominent, gradually raised, c. 17 mm long.</td>
<td>Male cone large, ovoid, sub conical, 18-43 cm long, 10-20 cm in diameter, orange in colour. Microsporophylls 40-50 mm long, 20-25 mm wide, fertile zone 30-34 mm long, apical spine stout, upturned, 22-30 mm long, entire, rarely forked.</td>
</tr>
<tr>
<td>Female cone</td>
<td>Megasporeophylls 15.3-33 cm long. Megasporeophyll lamina 5-9x2-4 cm regularly denticate on either side of the apical snout. Apical snout 1-4 cm long. Ovules 6-12, elliptic (3:2), 2.5-5.2x2-4.5 cm, green when young and orange to brown at maturity. Sarcotesta fleshy ca 3 mm thick, fibrous layer absent, sarcotesta stony, inner layer membranous. Spongy layer absent. Seeds platyspermic, germination cryptocotylar.</td>
<td>Megasporeophylls 20-25 cm long, persistently orangy-tomentose; ovules 3-8, glabrous; lamina lanceolate, 28-43 mm long, 18-20 mm wide, shallowly pectinate or regularly denticate, with 21-25 pungent lateral spines 5-10 mm long; apical spine distinct from lateral spines, 17-29 mm long, 4.5 mm wide at base. Seeds subglobose, 25 mm long, c.25 mm wide; sarcotesta yellow, fibrous layer absent; sarcotesta smooth; spongy endotesta absent.</td>
<td>Megasporeophylls tomentose, 12-19 cm long, lamina 70-85 mm long, 28-37 mm wide, lanceolate, dorsiventral; 13-25 lateral spines on either side, lateral spine entire, 4-9 mm long, apical spine 3.4-6 mm long. Ovuliferous region 6-12 cm long Ovules 1-6, glabrous, laterally compressed, spheroidal to broadly ellipsoid, 33-38 mm long, 35-39 mm in diameter, green when young, yellow at maturity, sarcotesta 4-5 mm thick, fibrous layer present, sclerotesta stony. Seeds platyspermic and germination cryptocotylar.</td>
</tr>
</tbody>
</table>
Key to the species of Cycas in India

1. Microsporophylls apex spinescent with one- to many-forking.
   2. Megasporophylls with long and broad apical spines (20-50×5-10 mm), tall and robust habit (50-92 cm in diam.), male cones large 18-43 cm long, microsporophylls apex with low degree of forking

   …………………………C. nayagarhensis

2. Megasporophylls with slender apical spine, tall and slender habit (12.5-32 cm in diam.), male cones small 11-21 cm long, microsporophylls apex with high degree of forking

   1. Microsporophylls apex entire without forking.
      3. Sarcotesta with a fibrous layer.
         4. Pinnae narrow (10-18 × 0.1-0.4 cm) with revolute margins, microsporangiate cones woody, persistent……………………………………………C. beddomei
         4. Pinnae broad (20-31.5 × 0.7-1.2 cm) with beak shaped or flat margin, deeply pectinate, microsporangiate cones massive 80 × 20 cm, microsporophyll with upturned spine, spines usually green and entire………………………………………………C. pectinata
   2. Sarcotesta without a fibrous layer.
      5. Pinnae midrib with a groove on the adaxial side, spongy layer present in seeds...C. zeylanica
      5. Pinnae midrib without a groove on the adaxial side, margins beak shaped, spongy layer absent in seeds.
            7. Margins of the lamina dentate with tough apical spine, apical spine, 0.3-2.5 cm long, ovules, 2-10, globose, 3.8-4.9 × 3.5-4.3 cm, pinnae with mucilage canals on the phloem side of the vascular bundles...............C. annaikalensis
            7. Megasporophylls lamina triangular, lateral spines soft, ovules, 4-10, globose, 2.5-4 × 2.3-4 cm, mucilage canals absent in the pinnae...............C. swamyi
   6. Megasporophylls lamina lanceolate, margin dentate, with or without distinct apical spine
      8. Megasporophyll without distinct apical spine………………C. indica
      8. Megasporophyll with distinct apical spine
         9. Megasporophyll lamina shortly dentate, apical spine distinct, ovules 6-10, flattened ovoid…………………………C. nathorstii
         9. Megasporophyll lamina dentate, apical spine distinct, mucilage canal present in pinnae
            10. Megasporophylls lamina dentate, apical spine distinct, ovules 3-8, spherical…………………………………C. sphaerica
            10. Megasporophylls lamina dentate, with apical snout 1-4 cm long, without a distinct apical spine, ovules 6-12, seed elliptic (3:2), 2.5-5.2 × 2-4.5 cm…………………………………C. circinalis

Figure 8. UPGMA dendrogram obtained through collective morpho-anatomical data, depicting the inter-specific relationship among the Indian Cycas. The branch lengths are based on the distance value computed using Jaccard’s coefficient of NTYSYS pc 2.02K software.
ACKNOWLEDGEMENTS

The authors are grateful to Ministry of Environment and Forests, Government of India for the financial support [AICOPTAX, No.J-22018/54/2000/CSC (BC)]. Mr. R. N. Reddy, IFS, Conservator of Forest, Odisha; Dr. Rekha Pai, IFS; Mr. Ashok Pai, IFS and Prof. S.P Adhikari are acknowledged for their kind support during field surveys.

REFERENCES


